Framework for Restoration of Heritage using Building Information Modelling

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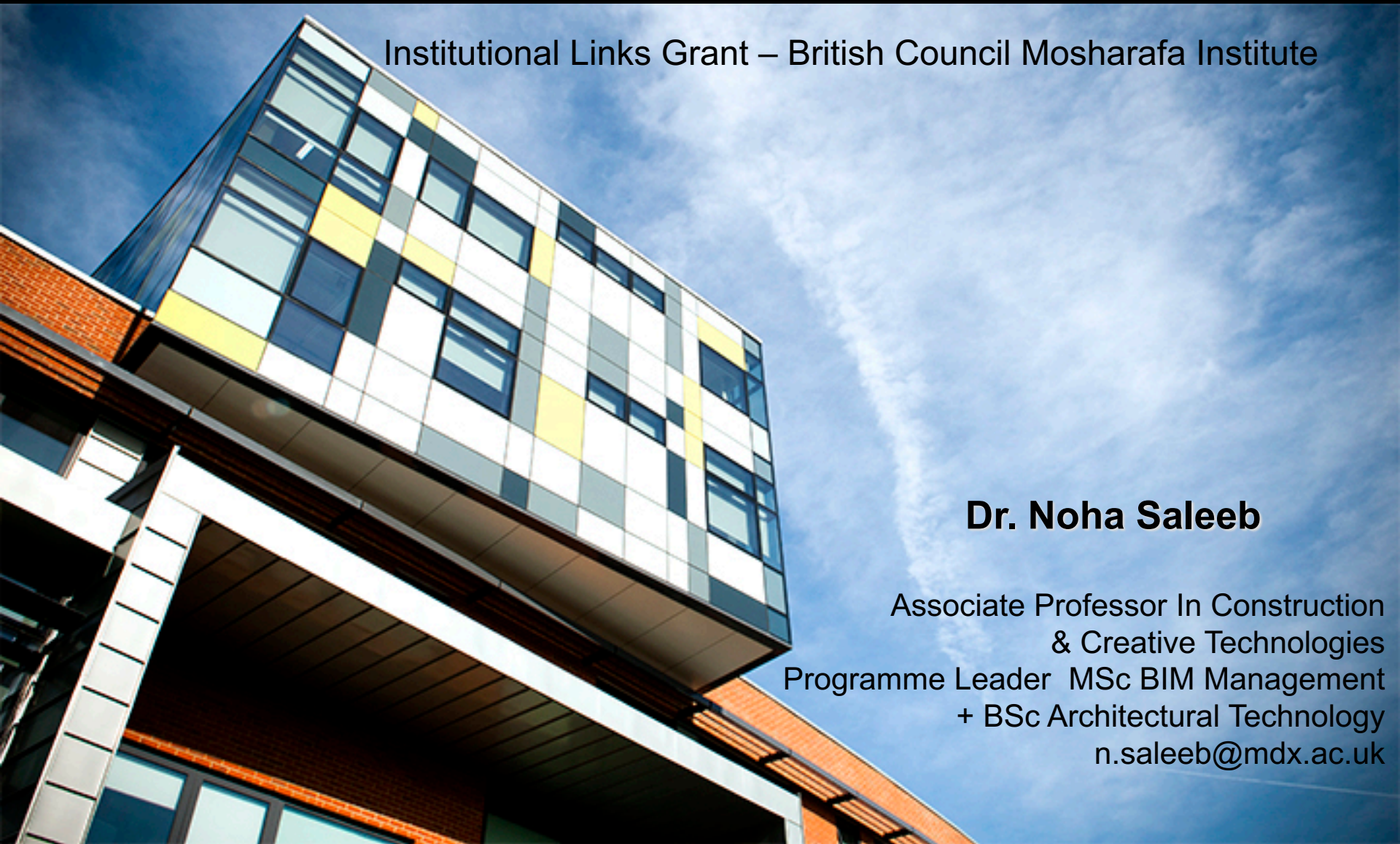

Institutional Links Grant – British Council Mosharafa Institute

Dr. Noha Saleeb

Associate Professor In Construction & Creative Technologies
Programme Leader MSc BIM Management + BSc Architectural Technology
n.saleeb@mdx.ac.uk

Agenda

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1. Why Classification ?
2. Classification vs. Measurement
3. What does Heritage need ?
4. Difference between different systems
5. Proposed Heritage Classification System

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Why Classification ??

What system does it belong to ?

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Complex ?
Rail / hospital...

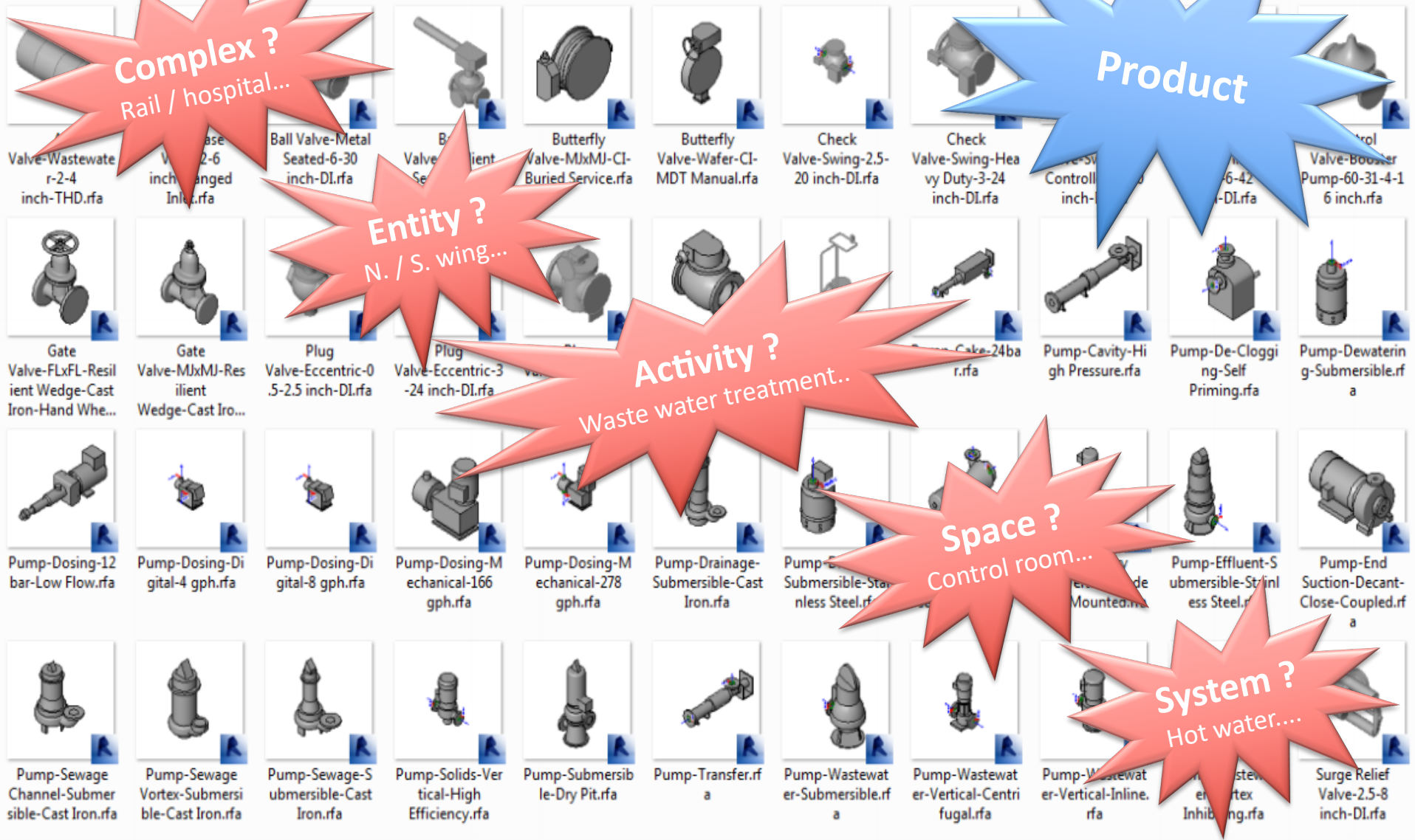
Product

Entity ?
N. / S. wing...

Activity ?
Waste water treatment..

Space ?
Control room...

System ?
Hot water....



What about.. Heritage ?

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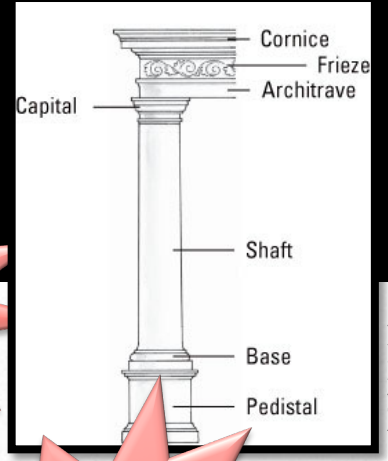

Complex ?

Condition ?

Entity ?

Cultural value?

Activity ?

Construction method?

Product

Space ?

Geometric ratio?

System ?

Architectural style ?

Benefits

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- Align with all stakeholder specifications and databases
- Alignment with manufacturer products, details and Product data sheets
- Organisation of maintainable asset data for FM and OM
- Classifications / libraries / databases for heritage object replacement for renovation
- Organised legacy data for comparison with other assets and reuse

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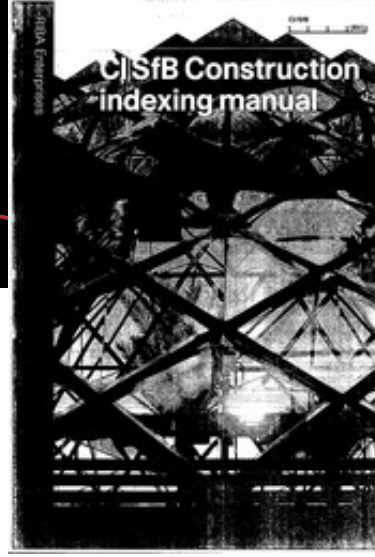
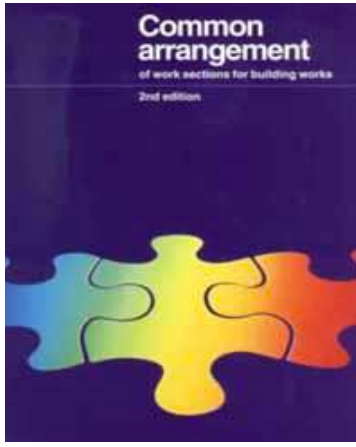
Classification vs. Measurement Systems vs. Thesaurus??

Classification Systems



CI/Sfb – Construction Index/Samarbetskommitten for Byggnadsfragor

- 1959 - Swedish committee for building investigation
- Basis of BS1192-5:1998 Construction Drawing Practice
- Library classification – lacking on specs & pricing mechanical/electrical services



CAWS – Common Arrangement of Work Sections (CPIC)

- 1987 – aligned with Uniclass (1997)
- > 300 sections
- Standardisation and coordination between bills of quantities & specifications
- Not ordered elementally - inappropriate for object naming in comp. models

SFG20 – Standard Maintenance Specification (Service and Facilities Group)

- 1990 – BESA
- Library of maintenance specifications for building engineering services (online available)
- > 400 schedules covering 60 equipment types (task schedules)

http://www.thenbs.com/

Classification Systems

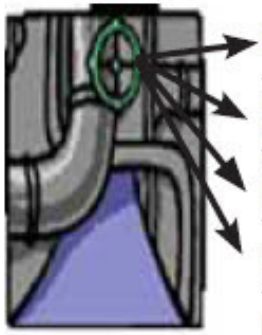
Omniclass

- 2001 – USA
- National BIM Standard (NBIMS) – initiative of BuildingSmart
- 15 tables based on ISO 12006 -2 (Organisation of Information about building ~Works – Framework for Classification)

Problems: tables differ in

- SCOPE: not all deal with arch, civil & process
- LEVELS of depth 2-8
- OBJECTS: in some tables a level is for groups of objects & individual objects
- Some MISALIGNMENT

Figure 6. OmniClass Object Identification

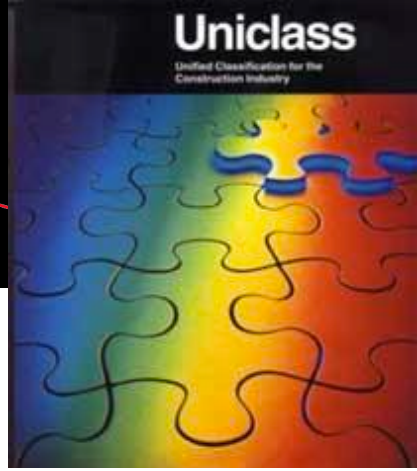


System	Condensate Return System	UniFormat, Table 21
Product	Ball Valve	Product, Table 23
Properties	Size Inch: 4	Properties, Table 49
Materials	Stainless Steel	Materials, Table 41

Condensed Return System | Ball Valve | VLV - 0001 - DC0000

Table code	OmniClass Table	Buildings & landscapes	Civil engineering	Process engineering
11	*Entities by Function*	***	**	**
12	*Entities by Form*	***	**	**
13	*Spaces by Function*	***		**
14	*Spaces by Form*	***		**
21	*Elements* (derived from UniFormat)	***		**
22	*Work Results* (derived from MasterFormat)	***	**	**
23	*Products*	***	**	**
31	*Phases*	***	***	***
32	*Services*	***	***	***
33	*Disciplines*	***	**	**
34	*Organizational Roles*	***	***	***
35	Tools	***		
36	Information	***	***	***
41	Materials	***	***	***
49	Properties	***	**	**
-	SectionFormat (outside	***	***	***

Classification Systems



Omniclass

Uniclass

- 1997 – by CPIc
- 16 tables based on CAWS, EPIC, CI/Sfb
- Aligned to ISO 12006-2

Problems: tables differ in

- SCOPE: not all deal with arch, civil & process
- LEVELS of depth 2-7
- OBJECTS: in some tables a level is for groups of objects & individual objects
- NO ALIGNMENT: individually created.
- CODING: some numeric /alphanumeric

Uniclass Table		Table code	Architectural	Civil engineering	Process engineering
Form of information		A	•	•	•
Subject disciplines		B	••	•	
Management		C	•	•	•
Facilities		D	•	•	•
Construction entities		E	••	•	
Spaces		F	•		
Elements	Buildings	G	••	•	
	Civil engineering works	H	•	••	
Work sections	Buildings	J	••	•	
	Civil engineering works	K	•	••	
Construction products		L	••	•	
Construction aids		M	••	•	•
Properties and characteristics		N	•	•	•
Materials		P	•	•	•
Universal Decimal Classification		Q	•	•	•
Computer aided draughting		Z	•	•	•

Classification Systems

Omniclass

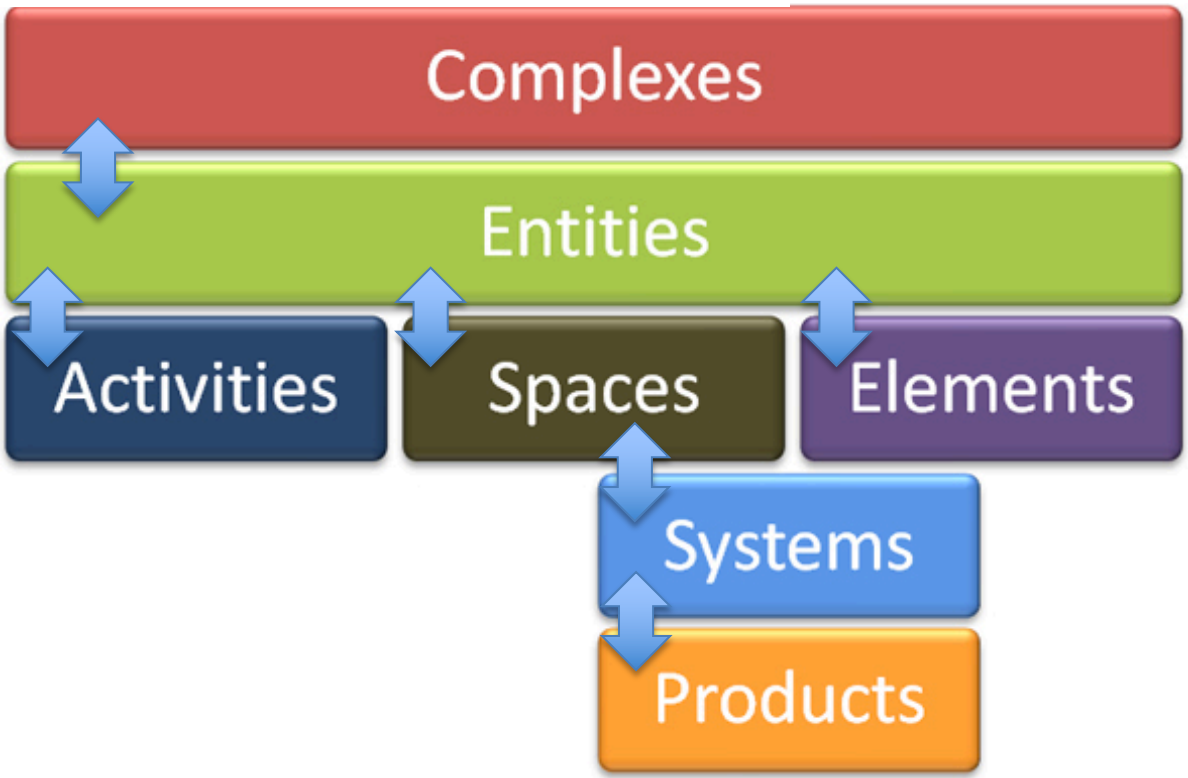
Uniclass

Uniclass 2

Table Reference	Title
Co	Complexes
En	Entities
Ac	Activities
Sp	Spaces
Ee	Elements
Ss	Systems
Pr	Products
WR	Work results

Figure 2 - Uniclass2 tables for construction information

- 2010-2015 – CPIc / NBS
- Complex – hospital → Entities - buildings, roads and landscape → Activity - surgical → Spaces – operations ward→ Element - roof→ Systems – HVAC → Products – ducts (oxygen..)
- Supports the creation of the built environment.

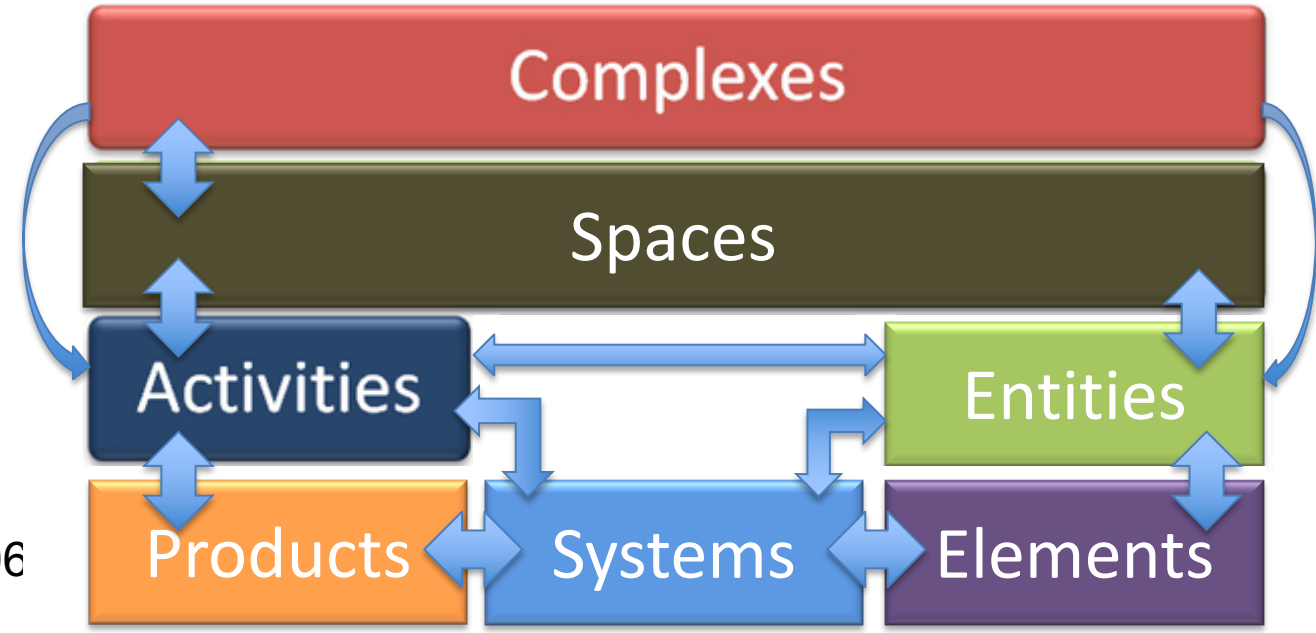


Classification Systems

- Omniclass
- Uniclass
- Uniclass 2
- Uniclass 2015

Table Reference	Title
Co	Complexes
En	Entities
Ac	Activities
Sp	Spaces
Ee	Elements
Ss	Systems
Pr	Products
TE	Tools & Equipment
Zz	CAD

?? - PM – Project Management / FI – Form of Information



- Includes: Buildings, engineering, landscape, infrastructure
- compliant with ISO 12006 2 - mapped to NRM1 (in PAS1192-4)

How does it work ?

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Ss - Systems

Ss_65	Ventilation and air conditioning systems	Level 1 class
Ss_65_40	Ventilation systems	Level 2 class
Ss_65_40_33	General space ventilation systems	Level 3 class
Ss_65_40_33_45	Kitchen extract ventilation systems	Level 4 class
Ss_65_40_33_48	Local extract ventilation systems	
Ss_65_40_33_50	Mechanical extract ventilation systems	
Ss_65_40_33_51	Mechanical supply ventilation systems	
Ss_65_40_33_52	Mechanical and whole building ventilation systems	
Ss_65_40_33_56	Natural ventilation systems	

23(!) different ventilation system categories

Measurement Systems

- ***Not strictly classification systems but MEASUREMENT systems***
- ***Map to classification systems e.g. Uniclass***

Contains

- ***Classification tables (not aligned/related)***
- ***Measurement units***
- ***Measurement rules***

Stages for NRM1, NRM2, NRM3

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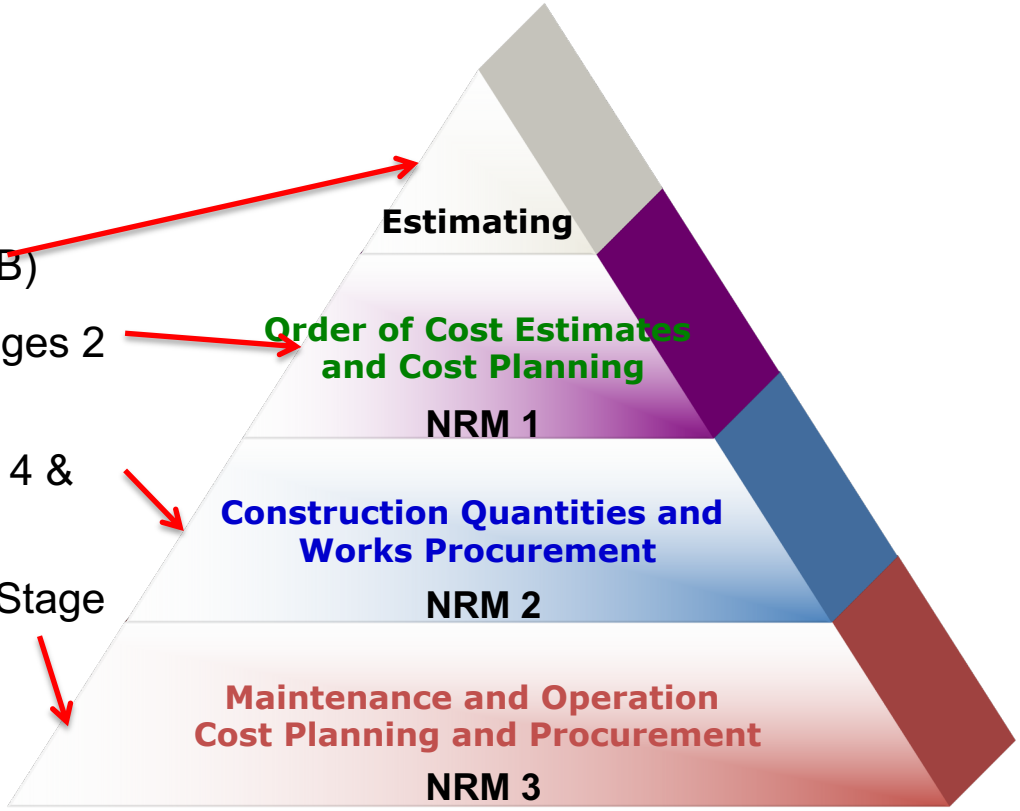
Project overview

A suited set of rules for:

- **Estimating**- RIBA Work Stage 0 & 1 (A & B)
- **Cost planning**- Elements- RIBA Work Stages 2 & 3 (C – E)
- **Works Procurement** - RIBA Work Stages 4 & 5 (F – K)
- **Maintenance Procurement** - RIBA Work Stage 6 & 7 (L)



All rules are developed in consultation with Clients and Practitioners.

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What does Heritage need ?

Characteristics of a Classification System

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- Online digital format
- Quick to use - allow rapid searching across all the tables simultaneously
- Free !!!
- Unified – tables not produced independently with associations
- One classification mode per table.
- Cross-sector - benefitting many disciplines in industry
- Full asset lifecycle (e.g. development, use, FM, demolition)
- Object hierarchy across all project phases and timeline
- Consider legacy classification systems
- Compliant with ISO 12006-2:2015
- Integration with barcoding developed by manufacturers for products.

More Hierarchical Attributes

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What's missing…

- *Architectural style / age*
- *Geometric information*
- *Construction restrictions*
- *Condition (deterioration, material durability etc.)*
- *Maintenance constraints*
- *Cultural / Heritage value*
- *Reflectance attributes.....*

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Difference between
Thesaurus – Classification – Taxonomy - Ontology

Classification vs. Thesaurus

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Definition

- ***Classification*** *is a process of categorisation, where ideas & objects are recognised, differentiated and understood.*

- ***Classification systems*** *are systems with a distribution of classes created according to common relations or affinities*

Classification vs. Thesaurus

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Definition

- ***Thesaurus*** *is a reference work that lists words grouped together according to similarity of meaning (synonyms and antonyms) - in contrast to a dictionary, which provides definitions for words*
- FISH: “A Thesaurus is a structured wordlist used to standardise terminology. It is used to assist in indexing and retrieving information within databases that make use of the same terminology.”

Roget, Peter. 1852. *Thesaurus of English Language Words and Phrases*.

Classification vs. Thesaurus

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Classification System	Thesaurus
Using symbols: numbers, letters or combination	Using natural language terms or words
Established relations between concepts – hierarchical representation of objects	Alphabetical listing and a systematic or classified display
Taxonomic: list one concept in one place only in the classification structure	Object can be listed more than once depending on synonyms
Levels of classification e.g. object → activity → function	Can have semantic levels. Any related relationships between terms are shown
Terms inside each hierarchical level are listed alphabetically	Navigation from non-preferred to preferred terms through synonyms

Classification vs. Thesaurus

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Examples of Thesauri

- ***Historic England**: Heritage Data – Linked Data Vocabularies for Cultural Heritage*

  http://www.heritagedata.org/blog/vocabularies-provided/

- *SMR Forum Scotland* *http://smrforum-scotland.org.uk/shed/data-standards/thesauri/*

- *FISH (Forum on Information Standards in Heritage) http://heritage-standards.org.uk/fish-vocabularies/*

Classification vs. Thesaurus

Vocabularies

We have used the STELLAR tools to convert the data to SKOS format, and each vocabulary has then undergone validation using the PoolParty SKOS validator service. There are direct links to the Linked Data vocabularies below, and the SKOS RDF files are also available for individual download. We have used the SKOS Play service to create additional downloadable alphabetical and hierarchical listings for each vocabulary.

Historic England

SCHEME	EXAMPLES	DOWNLOADS
FISH Archaeological Sciences Thesaurus Terminology used for recording the techniques, recovery methods and materials associated with archaeological sciences. Maintained by Historic England on behalf of the FISH Terminology Working Group.	MINERALOGY PEAT HUMIDIFICATION DENDROCHRONOLOGY	SKOS (RDF) Alphabetical (PDF) Hierarchical (PDF)
FISH Building Materials Thesaurus Terminology used for recording the main construction materials of monuments, buildings and structures relating to the built and buried heritage of the British Isles. Maintained by Historic England on behalf of the FISH Terminology Working Group	DOLOMITE FELT LEATHER	SKOS (RDF) Alphabetical (PDF) Hierarchical (PDF)
COMPONENTS (EH) Terminology covering divisions and structural elements of a building or monument	SPIRAL FLUTING STAIRCASE TRUSS	SKOS (RDF) Alphabetical (PDF) Hierarchical (PDF)
FISH Event Types Thesaurus Terminology used for recording	CORE SAMPLING DENDROCHRONOLOGICAL SURVEY BOX TRENCHING	SKOS (RDF) Alphabetical (PDF) Hierarchical (PDF)

A FRAME STEAM ENGINE
BT : **STEAM ENGINE**
SN : A simple, single cylinder vertical steam engine with its cylinder mounted directly on a baseplate, driving an overhead crankshaft which is supported by two A-shaped frames

AGED MENS WARD
BT : **BUILDING COMPONENT**
SN : Series of rooms within a workhouse where elderly men were housed.

AGIASTERIUM
BT : **INTERNAL AREA OR SPACE**
SN : The area of the Basilica, especially in the early church, in which the altar resides.

AGRAFE
UF : *Agraffe*
BT : **KEYSTONE**
SN : A keystone decorated with a relief sculpture, usually a cartouche

Agraffe
USE : **AGRAFE**

AILERON
BT : **GABLE**
BT : **PEDIMENT**
SN : A half gable or half pediment concealing the lean-to roof of an aisle.

Airing Yard
USE : **EXERCISE YARD**

AIR PUMP
BT : **PUMP**
SN : A pump for removing condensed steam from the condenser of a steam raising plant.

Air Shaft
USE : **VENTILATION SHAFT**

AISLE
BT : **STRUCTURAL COMPONENT**
BT : **PASSAGE**
NT : **AMBULATORY (INTERIOR)**
NT : **CARREL (AISLE)**
NT : **PASSAGE AISLE**
SN : The side compartment of a building, usually a church, hall or barn, separated from the main body of the building by an arcade; or a passage allowing access to rows of seats in an auditorium or church.

AISLE PLATE
BT : **WALL PLATE**
SN : A horizontal member along the length of an aisle wall to receive the ends of rafters.

AISLE TRUSS
BT : **TRUSS**
SN : A roof truss supported by arcade posts in an aisled building.

http://purl.org/heritagedata/schemes/eh_com
- AREAS AND SPACES
  - CHAPEL
    - APSE CHAPEL
    - CHANTRY CHAPEL
    - GALILEE
    - LADY CHAPEL
    - RADIATING CHAPEL
  - DANCE FLOOR
  - ENTRANCE
    - ADIT
    - CARRIAGE ENTRANCE
    - CREEP
    - CROSS ENTRY
    - DOORWAY
    - ENTRANCE HALL
    - GATEWAY
  - EXTERNAL AREA OR SPACE
    - AMBITUS
    - AMBULATORY (EXTERNAL)
      - CLOISTER
    - ANTEPORTICO
    - ATRIUM (ECCLESIASTICAL)
    - BAILEY
      - INNER BAILEY
      - OUTER BAILEY
    - BOATING POOL
    - COURTYARD
      - ANTECOURT
      - BASE COURT
      - CLOISTER GARTH
      - FORECOURT
    - COVERED WAY
    - EXERCISE YARD
    - PADDLING POOL
    - PARADISE
    - PARVIS
    - PERGOLA
  - INTERNAL AREA OR SPACE
    - AGIASTERIUM
    - AMBITUS
    - ANTECHAPEL
    - ANTECHOIR
    - APOTHESIS
    - ARENA
    - ATRIUM (SECULAR)
    - AUCTION ROOM
    - BAPTISTERY
    - CHANCEL
    - CHEVET
    - CHOIR
    - CLOSET
    - CONFESSIONAL
    - CORRIDOR
    - CROSSING
    - FERETORY
    - HAYLOFT
    - LOGGIA

Classification vs. Taxonomy

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Differences

Classification System	Taxonomy
Definition: systematic arrangement in groups or categories according to established criteria	**Definition**: giving names to objects or groups of objects according to their positions in a hierarchy
Criteria for hierarchy based on any external factors e.g. discipline, energy usage, structure, function, dimensions	Hierarchical relationships usually rely on internal characteristics inherent within the items themselves
Classification is not concerned with providing exhaustive lists	Taxonomies are more concerned with providing exhaustive lists
classification simply groups the items-- beneficial for defining a clear specification and codification of asset components	Taxonomies describe relationships between items

Ontology vs. Taxonomy

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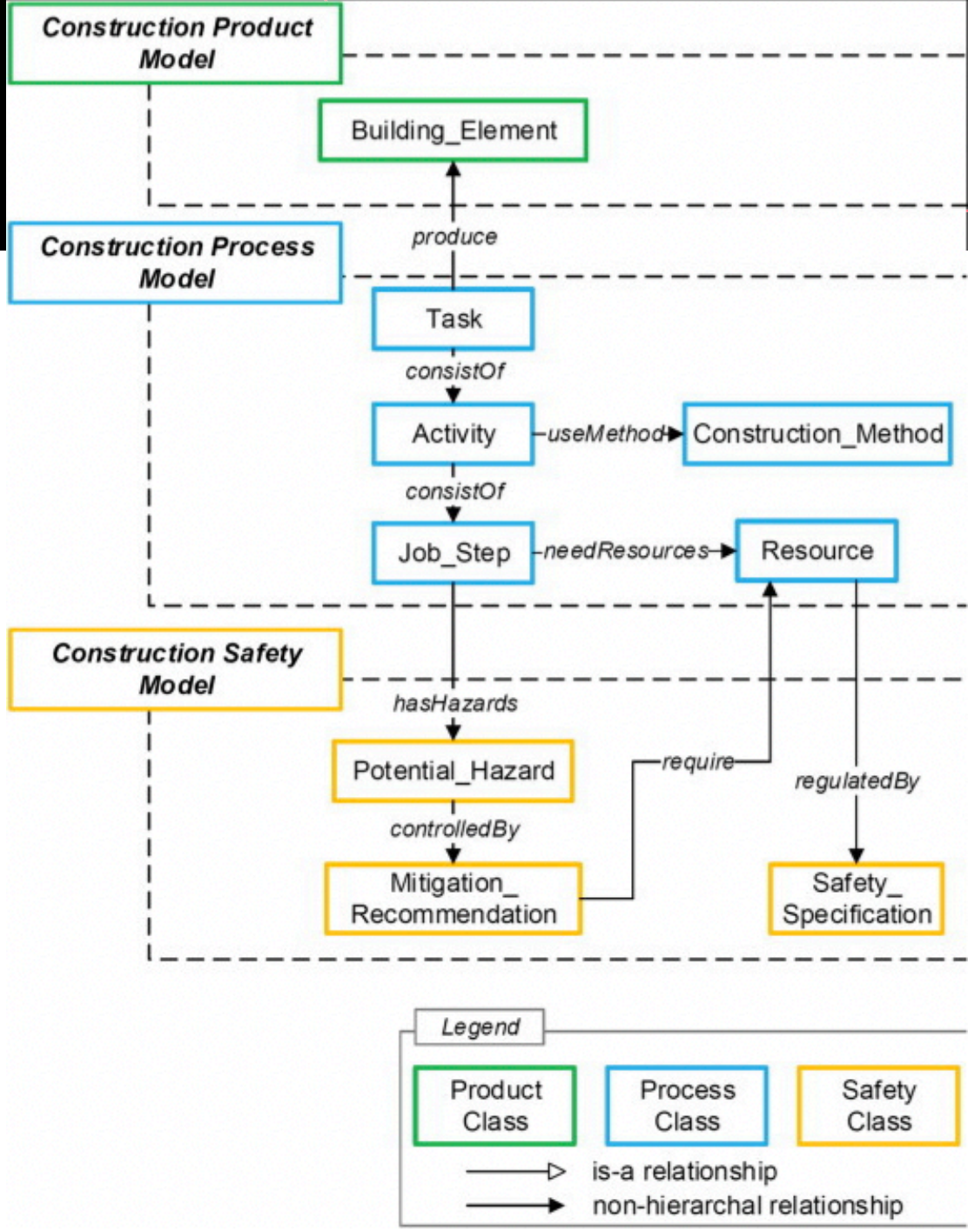
Ontology	Taxonomy
Highlights metadata of associative relationships between objects and intricacies between them	identifies relationships between items and categories, but lacks displaying the metadata of those items that can change the associations between them
Inference – e.g. connecting a type of window to a façade can have differing relationships based on architectural period, location and cultural aspects (e.g. privacy considerations of that era). Hence a relationship could be conditional, temporary or seasonal	Inference Non existent
Relationships and associations are not absolute – dynamic (live history and context of a Heritage building that affects how its components are refurbished and maintained, as opposed to a new build)	Taxonomy is a defined, static entity. taxonomy tries to simplify a complex collection of seemingly unrelated items into a linear, organization

Construction Related Ontology



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In conclusion

Ontological Classification System

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Non-exhaustive - allowing addition of new elements -
Attribute of Classification systems as opposed to Taxonomy

Non-semantic specific – focus is not on meaning of words and which terms are synonymous with each other, but on hierarchy

Also word mentioned once

Attribute of Classification not Thesaurus

Doesn't need associative relationships between child objects – the objective is clearly classifying the individual components of a building without complex parent & many to many relationships – ***Attribute of Classification not Thesaurus***

Concepts for hierarchical categorization preferred to be according to general criteria and external characteristics not based on internal inherent characteristics –

Attribute of Classification not Taxonomy

Inclusion of metadata, as per ontologies hence

Merge between classification and ontology schemes.

Ontological Classification System for Heritage

Heritage Ontological Classification
Classes & Subclasses

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Assembly Category

Structural components / Attached Architectural Components
Independent Components / Cladding

Orientation

Horizontal Support / Vertical Support / Inclined Support

System

e.g. Columns / Load bearing walls. / Sanitary Fittings

Type

e.g. Doric Architrave / Ionic Frieze / Retaining Walls / Sink

Composition

e.g. Concrete. / Stone / Brick / Timber / Steel

Example

Class 1 Assembly Category	Sub-Class2 Orientation	Sub-Class3 System	Sub-Class4 Type	Sub-Class5 Composition
Structural components	Vertical Support	Columns	Egyptian	
			Doric	
			Ionic	
			Corinthian	
			Tuscan	
			Islamic	
			Embedded Columns	Concrete
				Stone
				Brick
				Timber
				Steel
		Load bearing walls	Interior wall	
			Exterior wall	
			Retaining wall	
		Interior Stairs	Flying stairs	
			Honorary stairs	
			Spiral stairs	
		Exterior Stairs	Flying stairs	
			Honorary stairs	
			Spiral stairs	
	Horizontal Support	Beams	Simple support beam	
			Fixed beam	
			Cantilever beam	
			Continuous beam	
		Joists	Single Joists	
			Double Joists	
			Struss Joists	
		Lintels	Flat	
			Arch	
		Roofs	Flat roof	
			Gable roof	
			Hip roof	
			Shed Roof	
			Butterfly	
			Mansard	
			Gambrel	
			Perforated	
			Balcony	

PROTÉGÉ Classes & Sub-classes

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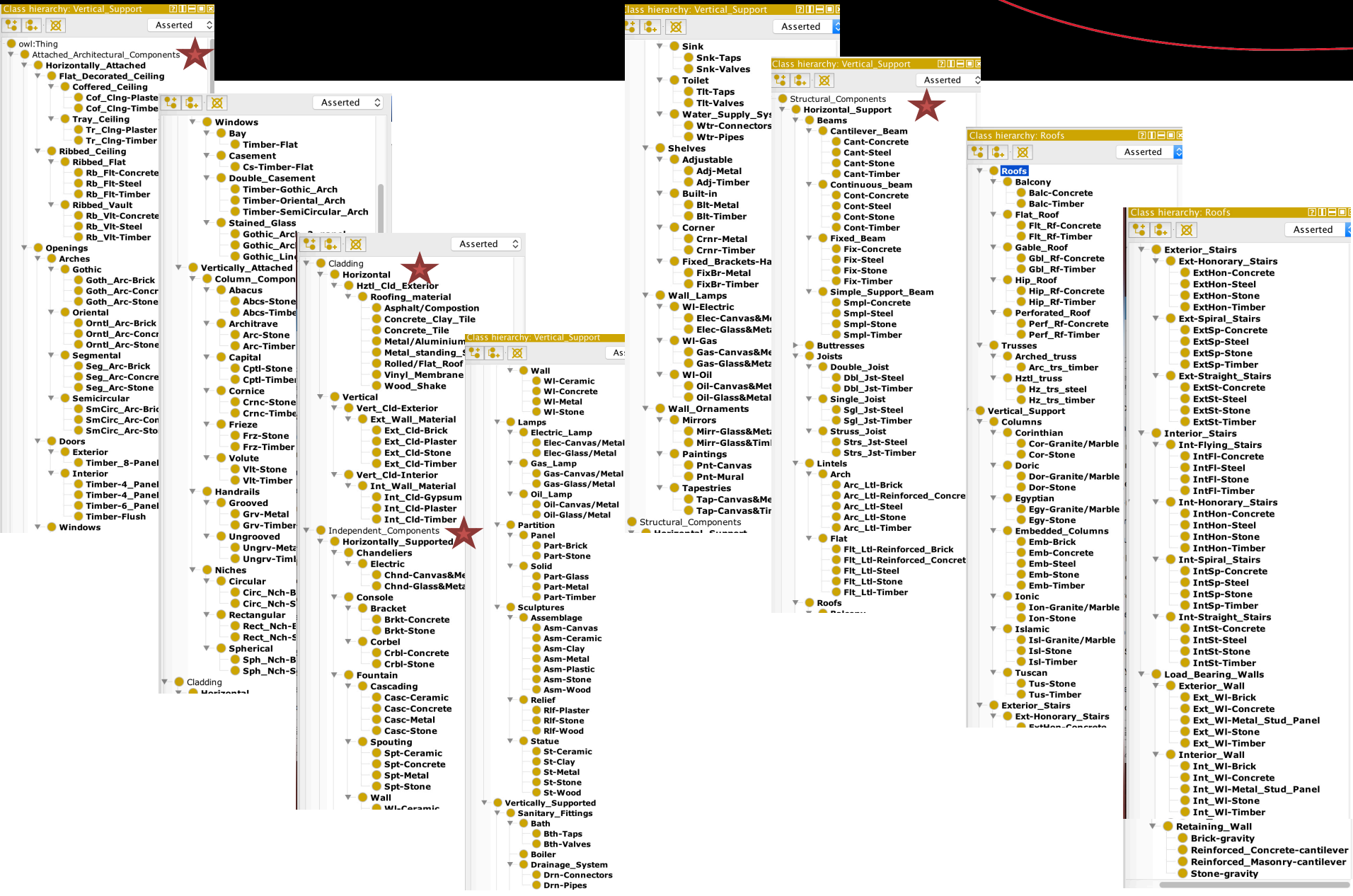

Next….

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1. Add *Data Properties* - which describe the common attributes for instances of a class i.e. the relationship between instances and their data values. In this case of sub-class level 5 giving the opportunity to document all the different components with their different characteristics that are actually available onsite.

2. Add *Object Properties* - which describe the relationship between the instances of the different classes / sub classes and each other at sub-class 3 level. These change the relationship and relevance between different components from one heritage asset to another hence affect the way these components are maintained

Data Properties to add to Sub-class 5 ”Composition”

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1. Code ID
2. Architectural style
3. Age
4. Geometric ratio
5. Origin
6. Material name
7. Allowed stresses / load bearing
8. Construction method
9. Condition (deterioration)
10. Life expectancy
11. Maintenance constraints
12. Cultural Heritage value
13. Reflectance
14. Space function

Class 1 Assembly Category	Sub-Class2 Orientation	Sub-Class3 System	Sub-Class4 Type	Sub-Class5 Composition
Structural components	Vertical Support	Columns	Egyptian	
			Doric	
			Ionic	
			Corinthian	
			Tuscan	
			Islamic	
			Embedded Columns	Concrete
				Stone
				Brick
				Timber
				Steel
		Load bearing walls	Interior wall	
			Exterior wall	
			Retaining wall	
		Interior Stairs	Flying stairs	
			Honorary stairs	
			Spiral stairs	
		Exterior Stairs	Flying stairs	
			Honorary stairs	
			Spiral stairs	
	Horizontal Support	Beams	Simple support beam	
			Fixed beam	
			Cantilever beam	
			Continuous beam	
		Joists	Single Joists	
			Double Joists	
			Steel Joists	
		Lintels	Flat	
			Arch	
		Roofs	Flat roof	
			Gable roof	
			Hip roof	
			Shed Roof	
			Butterfly	
			Mansard	
			Gambrel	
			Perforated	
			Balcony	

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Object properties

Data properties

PROTÉGÉ Onto Graf (3D)

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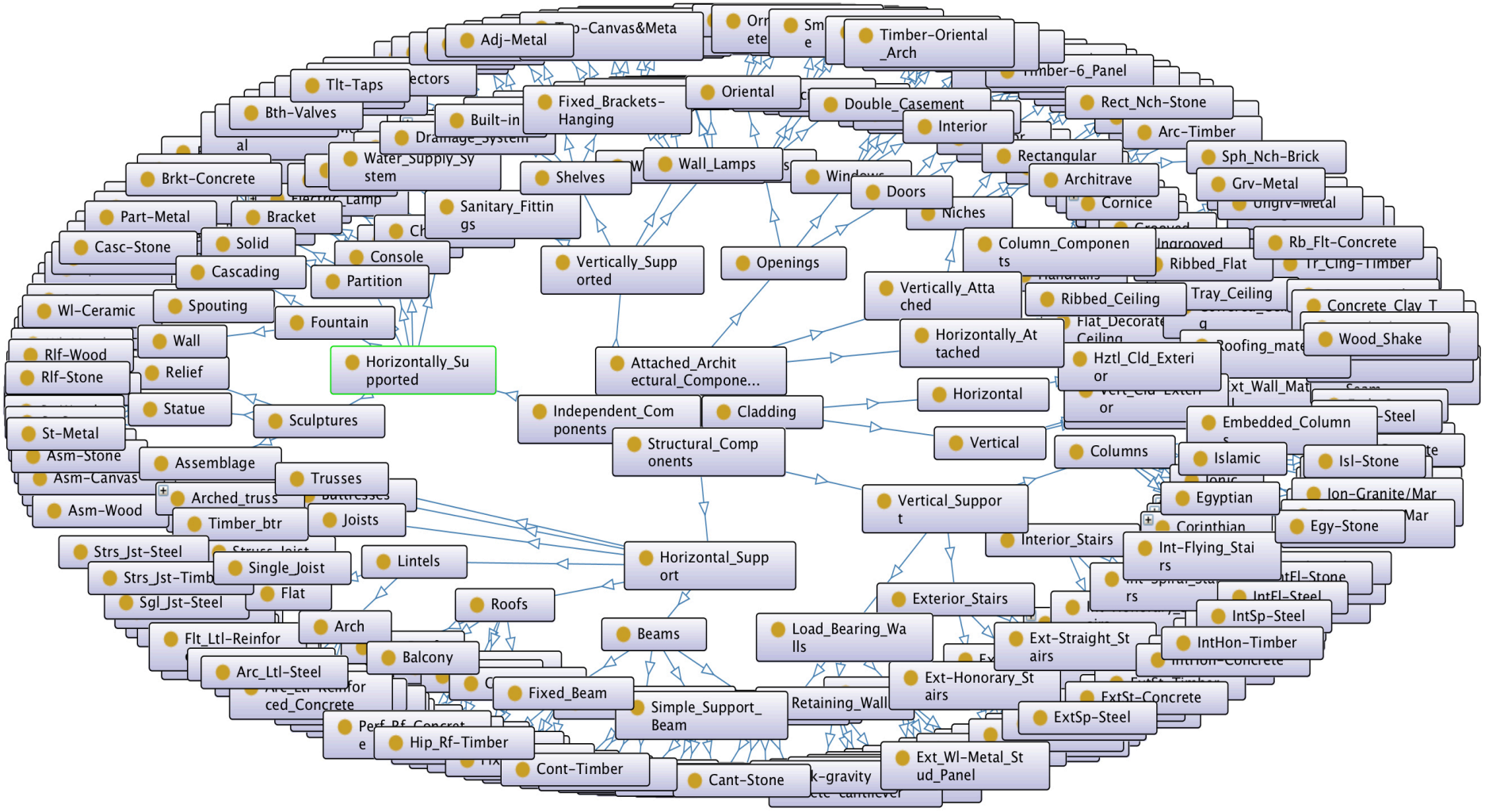
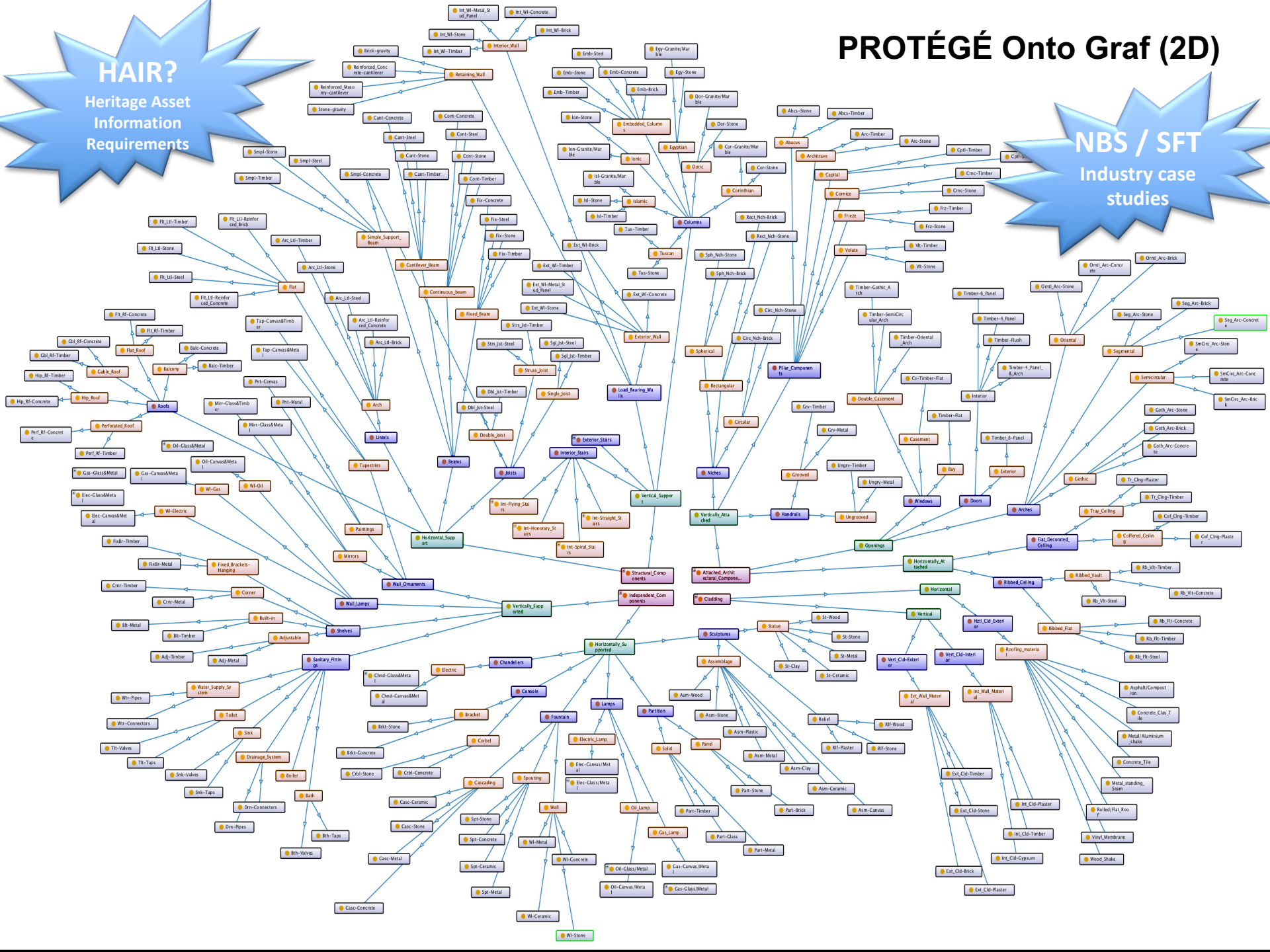


PROTÉGÉ Onto Graf (2D)

HAIR?
Heritage Asset Information Requirements

NBS / SFT
Industry case studies



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Questions

Middlesex University London

Dr. Noha Saleeb n.saleeb@mdx.ac.uk